

## **Engagement in Practice: Evaluating and Enhancing the Global Capstone Course**

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## **Engagement in Practice: Developing, Assessing, Evaluating and Enhancing a Global Engineering Capstone Course**

### **Introduction**

As society becomes more globalized, engineers will need the knowledge, skills, and attitudes to work effectively across cultural and societal differences. The Civil Engineering Global Capstone (Global Capstone) course sequence at The Ohio State University (OSU) is a culminating experience that offers students an opportunity to work collaboratively on real world engineering projects in collaboration with international institutions and communities. The overarching aim of the course sequence is to prepare students for the multidisciplinary, multicultural environment that they will experience upon entering the workforce.

The swiftly changing world has inspired a review of how engineering courses are preparing students for the globalizing workforce (1-4). Engineers will engage with others with diverse backgrounds involving education, culture, language, and experiences (3). This will require skills beyond the technical competencies students gain from their traditional coursework and include intercultural and social skills (2).

The Global Capstone course sequence was created to meet the increasing student demand for projects with a humanitarian engineering context and to develop the global competencies required for students to successfully complete these projects. The demand was created due to the number of OSU students pursuing a Humanitarian Engineering Minor and/or the Global Option distinction. Students in these programs are required to participate in a capstone design experience that involves a global or humanitarian focus.

This paper will:

1. outline the Global Capstone course sequence development process,
2. describe the structure and learning outcomes of the Global Capstone course,
3. reflect on the challenges associated with managing a program focused on complex real-world projects, and
4. propose a continuous improvement plan for the course sequence.

### **Course Development History**

The global capstone course sequence was created to give students an engineering experience in a real-world, global development context. This was first offered in the 2015-2016 academic year as a project option in a traditional civil engineering capstone (CE Capstone) course sequence for students interested in working on a humanitarian engineering project. The initial project was a water supply, treatment and distribution project in collaboration with a rural community in Tanzania. Due to the growth in popularity of the Tanzania project and minor differences in course deliverables that created student confusion, a separate section of the CE Capstone was offered in the 2017-2018 academic year for students working on the Tanzania project. The success of the separate section resulted in the development of the CE Global Capstone course sequence to further reduce student confusion about course requirements, eliminate prerequisite barriers for non-civil engineering students, and accommodate a growing number of students.

As shown in Table 1, the offering has impacted 122 OSU students representing seven different majors. The majors include civil engineering, environmental engineering, electrical engineering, agricultural

engineering, biological engineering, EEDS (Environment, Economy, Development and Sustainability) and data analytics. Also shown in Table 1, this course offering has consistently averaged a 50%/50% male to female student ratio in contrast to the approximate 80%/20% male to female student ratio in the department of Civil, Environmental and Geodetic Engineering where the course is offered. Additionally, the data in Table 1 show a consistent growth in the majors represented.

The Global Capstone course sequence now offers multiple project options with various international partners all focused on engineering aspects of sustainable development. Each year data were collected from the participating students that informed the instructors on how to improve the course for the following year. For example, the student feedback regarding conflicting deliverables between the traditional capstone and the global section was a primary factor that led to the creation of the stand-alone course.

**Table 1: Timeline for development of Global Capstone course sequence.**

<b>Academic Year</b>	<b>Course Framework</b>	<b># of Students</b>	<b># (%) of Male Students</b>	<b># (%) of Female Students</b>	<b># of Majors Represented</b>
2015-2016	Project within CE Capstone	6	4 (67)	2 (33)	1
2016-2017	Project within CE Capstone	17	12 (71)	5 (29)	1
2017-2018	Global Section of CE Capstone	17	9 (53)	8 (47)	2
2018-2019	Global Section of CE Capstone	24	10 (42)	14 (58)	3
2019-2020	CE Global Capstone I&II	24	10 (42)	14 (58)	5
2020-2021	CE Global Capstone I&II	34	15 (44)	19 (56)	6
<b>Total</b>	-	<b>122</b>	<b>60 (49)</b>	<b>62 (51)</b>	<b>7</b>

### **Global Capstone Course Structure**

The Global Capstone course sequence is a two-semester course sequence that is offered with a single-entry point in the autumn semester. The autumn semester has a one credit hour lecture component and one credit hour lab component with three total hours of contact time. The spring semester is a two-credit hour lab with a total of four hours of contact time. In addition to the scheduled class and lab periods, student teams, comprised of four to six students, are required to have one, 30-minute weekly meeting with the instructors.

Based on the demand and enrollment cap, students are required to apply for the Global Capstone before they can enroll. The application consists of both a written application and interview. The student teams are created based on student preferences, student skills, and project needs.

The projects offered in Global Capstone are driven by the needs of outside partners and are long-term in nature. This requires students to be able to engage in a project that has been worked on by previous student cohorts. Continuity is provided by the two instructors and dedicated industry consultant.

### **Course Learning Outcomes**

The Global Capstone learning outcomes for both courses in the sequence are aligned with the outcomes

of the traditional civil engineering capstone course but slightly modified to address the context of the projects in the course. The learning outcomes are as follows with the slight modifications in bold.

Upon successful completion of the Global Capstone course sequence, students will be able to:

1. Synthesize knowledge from their prior coursework to identify, formulate, and evaluate design alternatives in the context of a multidisciplinary **global civil engineering development project** that incorporate criteria such as economics, aesthetics, and social, cultural, political, and environmental issues and impacts.
2. Identify and collect information at the various stages of the design process necessary for the design of a **global development civil engineering project**.
3. Prepare engineering documents such as engineering drawings and general notes, technical reports, and proposals.
4. Prepare and present professional oral presentations for a variety of audiences.
5. Perform effectively as a member of a multi-disciplinary team.
6. Translate engineering skills and knowledge into the context of an **international development project**.

The syllabi for the courses also indicate that they contribute to the student achievement of the seven ABET Student Outcomes. (6)

### **Challenges of Offering the Global Capstone Sequence**

The Global Capstone provides students with an opportunity to work on real-world problems tied with actionable implementation. Offering such a course presents a variety of challenges. An informal assessment process was used each year to inform the course changes focused on mitigating the challenges identified. One of the most prominent challenges is the continuity of projects and partnerships from year to year. The Global Capstone was also significantly impacted due to COVID-19 but was still able to run in a modified form.

The following summarizes the challenges from a logistics standpoint, faculty perspective, and student perspective.

#### Project/Course Challenges

Global development projects present challenges beyond those of a traditional capstone project. These include:

- having project clients with different societal and cultural norms that requires student to develop solutions beyond the traditional western centric solutions they are familiar with,
- client communication barriers due to language, time zone, and technical limitations,
- lack of availability of information such as technical, economic, and statutory information,
- projects that require technical skills beyond those of the typical student due to the complexity and context, and
- students lack experience with the context of global engineering development projects.

#### Faculty Perceived Challenges

The teaching and corresponding management associated with offering a global capstone course presented challenges. These include:

- There was consistently more student interest in the course than capacity allowed.
- Scheduling demands of multiples majors and academic departments resulted in significant course enrollment conflicts.
- The challenge of educating new students on project status due to the continuity of projects from year to year.
- Students required additional support resulting in faculty needing to balance the extra time commitment expected by students while managing other institutional responsibilities.
- Capacity to manage projects and external relationships.
- Limited ability to travel to partner sites in pre-pandemic years and no ability to travel during the COVID-19 pandemic.

### Student Perceived Challenges

There were several themes to student perceived challenges identified through informal discussions and end of course instructor evaluations. These themes include:

- Lack of confidence in making design assumptions due to limited opportunities for communication with international partners.
- Managing the uncertainty and complex nature of global development projects.
- Learning skills required beyond their specific engineering discipline.
- Difficulties communicating and collaborating within and across groups.
- Transition of projects from year to year.

### **Proposed Assessment and Evaluation for Continuous Improvement**

To date, only an informal process using faculty course critiques and student evaluations have been used to improve the course. Moving forward, it is critical to assess and evaluate the extent to which the learning outcomes are being achieved and the growth in global competencies as a result of the intercultural nature of the course. In addition, to justify the additional faculty time and other resources, it is important to evaluate the added value of the course from the traditional capstone sequence.

Proposed assessment criteria and evaluation methods that will generate data that can be used to assess the impact on student learning for those enrolled in the Global Capstone course sequence in comparison to the traditional capstone sequence will be outlined in this section. The results of the assessment and evaluation process will be used to develop strategies for the continuous improvement of the course sequence. In addition, the sharing of lessons learned, and results of the continuous improvement plan will be shared publicly so others will benefit.

The following questions will be answered through the assessment and evaluation plan.

1. How do engineering students enrolled in both global and traditional engineering capstone design courses perceive and experience working in multidisciplinary teams?
2. How do engineering students enrolled in both global and traditional engineering capstone design courses perceive and experience working on projects within a multicultural context?
3. How do the student experiences in both global and traditional capstone sequences compare with respect to student achievement of course learning objectives and the associated ABET Student Outcomes?
4. How do the student experiences in both global and traditional capstone sequences compare with respect to student development of intercultural competency?

## Evaluation Methods

The qualitative and quantitative evaluation methods will be implemented with the goal of evaluating the effectiveness of the course in achieving the learning outcomes by understanding the differences in student experiences in the various engineering capstone courses. The process proposed follows the methodology aligning with case studies and action research proposed by Case and Gregory (7). The data collection will consist of informal observations, a combination of Likert scale and open-ended surveys, and student feedback through formal course evaluations. The surveys were developed using the SALG assessment tool (8).

## Development Timeline for Assessment and Evaluation Plan

Table 2 summarizes the proposed timeline for the development of the assessment and evaluation plan for the Global Capstone course sequence.

**Table 2: Timeline for development of the assessment and evaluation plan.**

Task	Expected Start	Expected Completion
Literature review on assessments methods	7/20	11/20
Develop written survey questions	12/20	6/21
Disseminate semester 1 survey	8/20	11/20
Analyze semester 1 written survey responses	1/21	2/21
Disseminate semester 2 survey	3/22	4/22
Analyze data and report findings	5/22	6/22
Develop enhancements to courses	6/22	8/22
Implement changes to courses	8/22	4/23

## Pre and Post Course Student Surveys

The assessment and evaluation plan will compare the CE Capstone, Food, Agricultural, and Biological Engineering Department (FABE) Capstone and Global Capstone courses. The surveys were created by using existing, validated survey tools and incorporating the existing course objectives and ABET outcomes into the survey tools. The first year of the initiative has been dedicated to literature review, survey development, and observation protocols. The survey assessment tools will be implemented in a pre- and post-course assessment approach. The benchmark assessments will be administered at the beginning of the autumn 2021 semester followed by assessments at the end of the autumn and spring semesters. The pre/post-course surveys include questions about working on multidisciplinary teams, working on projects in a multicultural context, self-assessment of skills corresponding to the course learning objectives, self-assessment of intercultural competency, and self-assessment of contribution to achieve the ABET student outcomes. The pre-course survey also includes questions about student demographics. In addition to the surveys, faculty assessment of student work and observation of behaviors will be used to directly assess achievement of course learning objectives, ABET student outcomes and intercultural competency.

## Conclusions

By understanding the nuanced nature of working in a multidisciplinary and multicultural context in the engineering capstone courses, enhanced student learning outcomes and assessments can be developed to support the preparation of engineers entering the workforce. With the knowledge gained through

this research the Global Capstone course sequence can be evaluated in terms of its effectiveness as compared to the other capstone courses to inform changes that can be made to the Global Capstone.

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